METHOD AND APPARATUS FOR PACKAGING MATERIAL UNDER COMPRESSION AND THE PACKAGE MADE THEREBY

RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional application no. 60/438,293 filed January 7, 2003, U.S. Provisional application no. 60/420,331 filed October 23, 2002, and U.S. Provisional application no. 60/409,988 filed September 12, 2002. The entire contents of each of these applications is hereby incorporated by reference herein.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[Not Applicable]

REFERENCE TO A SEQUENCE LISTING

[Not Applicable]

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] This invention relates to handling material, especially packaging sheet or strip material. More particularly, this invention relates to forming packages of wound sheet or strip material under compression.

2. Description of Related Art

[0003] The material handling industry is focused on handling different types of materials efficiently, at the lowest possible cost while maintaining material integrity. Handling batting has a long history and has evolved as batting materials have changed. Before the advent of synthetic materials, batting consisted of cotton or wool fiber wadded into rolls or sheets. These sheets were called wadding, which is a soft layer of fibrous cotton or wool, used for padding or stuffing. Such stuffing was used for a variety of items, ranging from furniture, mattresses, bedding, or even feminine hygiene products and other medical items that required absorbent material.

[0004] A common way traditional wadding was handled included compressing the wadding and rolling it into a roll. This technique was based on the method of making cotton bales. For example, U.S. Patent 546,009 to Graves discloses a method of forming a cylindrical cotton bale in which cotton flakes are blown from a chute of a cotton gin onto a

condensing cylinder to form a bat. The bat is compressed by rollers and passed down a guide to a compression roller. The tightly compressed bat is passed to guide rollers and between a belt and spindle. The belt causes the bat to be spirally wound on the spindle thereby applying pressure to each layer in the bale.

[0005] As the materials became more sophisticated, the method of handling the material evolved. For example, U.S. Patent 2,353,821 to Fourness et al. describes the method of making a compressed wadding roll using, in one example, "white" wadding used largely in the manufacture of sanitary pads. As noted in Fourness, such "white" wadding is lively and must re-expand before its conversion to sanitary pads, which require a very uniform product. The apparatus of Fourness was designed as an adjunct to a wadding compressor in which compressed wadding is fed to the device to wind the compressed product into a roll ready for storage and shipment. The winding apparatus includes upper and lower transfer plates that transfer the compressed wadding to the throat of the winder where it is caught in the nip of the winder belt and core. Fourness' device packaged compressed wadding in lengths of nine feet or more so that short pads for individual sanitary napkins could be cut from the roll.

[0006] While methods to handle wadding made of cotton or wool were developed so that rolls were made that were easier to transport and handle, the material itself had its limitations. Severe compression of cotton wadding caused the material to become "planky" or stiff. Textile wadding was not well suited for single use applications as it is expensive. It was also bulky and costly to handle and transport.

[0007] In response to these problems, nonwoven fibrous materials suitable for household and industrial use were developed in the 1960's and 1970's. By the mid to late 1970's, nonwoven fibrous materials had developed to the point at which they became accepted as replacements for conventional textile fabrics. Such nonwoven sheets possess properties similar to conventional textiles in terms of strength, bulk, flexibility and softness, but are less expensive and especially suited for single and limited use applications. Nonwovens became commonplace for use as household and industrial wipers and for components in sanitary napkins and disposable diapers. Now, nonwovens have gained wide acceptance and are in common use as protective garments, including sanitary napkins and diapers, wipers, health care items, including bed linens and surgical drapes, filtration media, and automotive items, for example. Nonwovens can also be used in garments, such as jackets and raingear, and linens, such as draperies, comforters, and mattress covers.

[0008] Manufacturing nonwoven materials is very different than making bales of cotton in which cotton flakes are blown onto a compressor or cotton or wool fibers are matted together into bats. Thus, new techniques were created to form these nonwoven materials. At the initial phases of nonwoven development, a technique was proposed that included forming a fabric scrim with fibers attached thereto, as disclosed in U.S. Patent 2,900,980 to Harwood. Although this product had a soft feel, it was expensive as the majority of the material was formed by textile length fibers, rather than the less expensive short cellulosic fibers. Therefore, new processes were developed to use the short inexpensive cellulosic fibers to create a web of material. The techniques developed in the 1970's for making nonwovens focused on using short cellulosic fibers that were delicately entangled and created a product that had different inherent characteristics than traditional textile fabrics.

[0009] One technique employed an air-laid web that blends randomly arranged and intermingled short cellulosic fibers and longer reinforcing fibers permanently bonded together with a binder, which then sets to form a finished web having a predetermined density and loft. See, for example, U.S. Patent 4,127,637 to Pietreniak et al.

[0010] Another air laid technique, disclosed in U.S. Patent 4,100,324 to Anderson et al., mechanically entangled fibers by merging a primary air stream of melt blown microfibers and a secondary air stream of wood pulp fibers under turbulent conditions.

[0011] An ultrasonic technique described in U.S. Patent 4,109,353 to Mitchell et al. passed fibrous webs through a vibrating nip in the presence of uncombined liquid. Movement of the liquid within the web causes rearrangement and entanglement of the fibers resulting in a web that has desirable strength, drape and softness.

[0012] A chemical technique extruded a thermoplastic polymer into filaments with a lubricating agent, collected the extruded filaments in a web, and applied heat. See, for example, U.S. Patent 4070218 to Weber.

[0013] These techniques were developed to enhance material properties, such as porosity and absorbency, that are highly desirable in nonwoven sheets. To provide sufficient absorbency, it is important to have internal channels for fluid flow through the material. Softness and aesthetic appearance are also important properties so that the nonwovens can approximate conventional textile fabrics and not be stiff and paper-like.

[0014] As discussed in U.S. Patent 3,978,257 to Ring, it was discovered in the 1970's that the conventional papermaking processes used for producing fibrous materials that used

water for laying fiber and creating interfiber hydrogen bonds formed materials that were stiff, harsh and had low absorbency. Thus, subsequent processing steps were required, such as creping, to soften the material and increase its absorbency and bulk by breaking some of the interfiber bonds and opening the surface and internal structure.

[0015] On the other hand, air laying processes generally employed adhesive for interfiber bonding. Adhesive content was increased to increase strength, and the material was compressed to insure that the short fibers were bonded. This also resulted in increased stiffness and the reduction of the size and frequency of fluid retaining spaces between the fibers, thus reducing absorbency. So, it became common to enhance softness of a fibrous web by creping and controlled compaction to work the fibers. Nonwoven webs were also embossed using special techniques to improve strength. Another process used to increase the absorbent rate was to brush the layers of material to remove loose fibers and open the internal pore structure.

[0016] Thus, handling and processing nonwoven materials is far more complex than conventional textile fabrics. The types of fibers vary, and many nonwovens use a combination of different types of fibers, such as a synthetic fiber and natural fiber mix. Also, the entanglement of the fibers is significant. It is important to obtain the optimum entanglement for strength while trying to minimize stiffness and enhance absorbency. If the material is handled too roughly prior to the end manufacture, the delicately entangled fibers will become damaged and the properties will change.

[0017] The following physical properties of nonwovens are often measured to assess the material's suitability for certain applications. Uncompressed thickness is measured using an approved thickness tester. Bulk density is calculated using the measured uncompressed thickness and sample basis weight. Oil and water absorbency is tested by placing a previously weighed sample of material in a bath and then removing and draining the material. The drained material is then weighed again and the differential is divided by the density of the liquid and then by the dry weight of the material sample to obtain an absorbency level. Dry and wet breaking length is calculated by measuring tensile strength of a dry or wet material sample that is divided by the basis weight of the sample. Stretch can be determined by using the increasing length measured during the tensile strength test and percentage increase in length of the sample just prior to breaking. Lint count is obtained by bending, twisting and crushing a sample over a filter and then measuring the particles trapped by the filter. Specific volume is determined by dividing the uncompressed thickness by the basis

weight of the sample to determine the initial specific volume. The sample is then compressed to a certain value and the compressed thickness is measured and divided by the basis weight to determine the loaded specific volume. The recovered specific volume is determined by measuring the recovered thickness of the sample after the load is removed divided by the basis weight.

[0018] The properties of nonwoven materials are monitored closely by nonwoven manufacturers to ensure that the material is consistent and meets the requirements of an end user, such as a diaper or sanitary napkin manufacturer. These considerations also apply to nonwoven materials that are made of foam, for example, rather than interlocked fibers.

[0019] After forming the nonwoven web, the material is rolled onto a master roll, which can then be transported for use or split into smaller sheets or strips used to make smaller rolls of material. These rolls are spiral wound into what is commonly called a pancake roll, represented in FIG. 2. It is important that the initial characteristics of the material obtained upon its manufacture be maintained during subsequent processing and transport. For instance, nonwoven material intended to be manufactured into to diapers must be handled in a way such that it arrives at the diaper manufacturer with its initial manufactured characteristics, especially as to product performance.

[0020] Conventional methods of handling wadding discussed above manipulate the material to compress it to make a more compact package that is easier to handle and less expensive to transport and store. These techniques are still used for packaging such things as insulation formed of felts of mineral fibers, as disclosed in U.S. Patent 5,305,963 to Harvey, III et al. and U.S. Patent 5,425,512 to Bichot et al., for example. However, such compression techniques using nips and compression plates that are suitable for fibrous materials in which material integrity is not critical cannot be used with modern nonwovens as the internal structure of the nonwoven material is damaged using conventional compression techniques.

[0021] Compression using a nip or plate, as used in compressing insulation, applies a large pressure in a small area of the sheet. Such an application of pressure in a concentrated area tends to damage nonwovens by breaking fibers. This is illustrated in FIG. 3 in which a compressible sheet 210 is pressed by a compression belt 220 at a compression point P, which breaks fibers at that point. FIG. 4 shows a compressible sheet 230 pressed by nips 240 at a compression point P, which also breaks fibers at that point. Damage to the nonwoven structure can adversely affect its rebound, strength, stretch and absorbency, among other

qualities. In particular, if the delicately entangled fibers are broken or the cells of a foam are crushed, the fluid path is compromised.

[0022] Thus, to avoid damaging the material, nonwovens are presently wound on rolls with no significant compression, which results is large rolls that are difficult to handle and expensive to transport and store. FIG. 2 shows a conventional pancake roll 200 wound with no compression. Section B of FIG. 2 shows the fibers of the nonwoven being in their original entangled state. Even winding without compression can create problems in spiral wound rolls in which the inner layers can be unevenly pressed by the outer layers.

[0023] Additionally, winding compressible material under tension to obtain a larger run of material on each roll is not effective. Placing nonwoven compressible material under tension can also damage the internal fibers by breaking them and thus cause performance of the material to degrade.

[0024] Other methods to obtain a compressed roll to reduce its volume for storage and transportation have also been problematic. For example, compressing the wound package after forming the roll causes the roll to have a reduced diameter, which in turn reduces the circumference of the each wound layer. This forces the layers inwardly toward the core and creates creases or folds in the layers in order to reduce the circumference. A result is inconsistent compressing and potential damage to the material.

[0025] There is a need, therefore, for a method and apparatus that can efficiently package nonwoven material while maintaining its manufactured characteristics. It would be desirable to form a compressed package of nonwoven material in which air is removed from the wound layers while the material experiences no damage.

SUMMARY OF THE INVENTION

[0026] An aspect of this invention provides a significantly compacted roll of nonwoven material that has material characteristics suitable for an end use manufacturer.

[0027] Another aspect of this invention provides a package that is less expensive to transport and store due to its compacted size.

[0028] An additional aspect of this invention provides a method of winding an uncompressed nonwoven sheet of material into a roll under compression controlled to significantly reduce the thickness of the sheet with no damage to the material. The method also includes forming plural compressed rolls on a single core.

[0029] A further aspect of this invention provides an apparatus for compression winding a package in conjunction with a traverse winding assembly.

[0030] Another aspect of the invention provides a package formed of a compressed traverse wound roll or a plurality of pancake rolls on a single core.

[0031] An additional aspect of the invention provides a method of controlling compression of a package of nonwoven compressible material based on the inherent characteristics of the material to maximize compression and minimize material damage.

[0032] A further aspect of the invention is to provide a package in which the material is under substantially uniform pressure throughout. The compressed material is not under tension. The apparatus for making the package can have a controller that balances compression with the material properties. The method of making such a package includes the step of controlling the compression on each layer of the package.

[0033] The invention provides a package comprising a core having a length and strip material having a width less than the length of the core wound in a traverse pattern over substantially the length of the core under compression, wherein the strip material is under substantially uniform pressure throughout the entire package. The material may be nonwoven and may be continuous.

[0034] The invention also provides a package comprising a core having a length and strip material wound on the core under compression in a pattern of a plurality of stacked rolls with stepped interconnected strip portions between each roll on the core, wherein the strip material is under uniform pressure throughout the entire package. The strip material may be nonwoven and material and may be continuous.

[0035] The invention further provides a package comprising a core having a length and strip material wound on the core substantially across its length, wherein the strip material has a thickness, is nonwoven, has substantially no tension, and is compressed to substantially reduce the thickness. The pressure on each layer is substantially uniform throughout the entire package.

[0036] The invention additionally provides a method of forming a package wherein strip material is formed into a roll supported by a core, comprising feeding an uncompressed strip of material to the core and winding the strip onto the core with a driven belt that substantially surrounds the core to wrap the strip around the core with the strip under

compression. The strip may be wound on a single core, plural strips may be wound on a single core, or plural strips may be wound on plural cores.

[0037] The invention also provides a method of forming a package, comprising feeding a sheet of material to a packaging apparatus having at least one core and at least one driven belt that substantially surrounds the core, separating the sheet into a plurality of strips, driving the belt under tension, and winding each strip onto a core with the belt thereby compressing the strip and forming a package under uniform pressure throughout. The sheet may be uncompressed or precompressed when fed to the apparatus.

[0038] The invention provides an apparatus for forming a package of strip material wound on a core under compression, comprising a winding device having a frame, a longitudinal core support mounted to the frame, and a driven belt supported by the frame to substantially surround the core and a strip material feeding apparatus disposed adjacent to the winding device and including a traverse feeder that moves the strip material longitudinally with respect to the core. The driven belt is controlled to wind the strip material onto the core under compression. The apparatus can include a material separator that separates the strip material from a sheet of material.

[0039] The invention further provides an apparatus for forming a package of strip material wound on a core under compression, comprising a winding device comprising a frame, a longitudinal core supported by the frame, and a driven belt supported by the frame to substantially surround the core and strip material feeding apparatus including a material separator that separates strips from a sheet of material, wherein the separated strip is wound onto the core by the driven belt.

[0040] The invention additionally provides an apparatus for forming a package of strip material wound on a core under compression, comprising a frame, a longitudinal core supported by the frame, a driven belt supported by the frame to substantially surround the core, and a controller coupled to the driven belt that adjusts tension of the belt based on parameters of the strip material so that fibers in the compressed strip material do not break.

[0041] These and other aspects of the invention will become apparent from the description herein taken in conjunction with the drawing figures.

DESCRIPTION OF THE DRAWINGS

[0042] Referring to the drawings that form part of this original disclosure:

[0043] FIG. 1 is a side view of a package formed in accordance with this invention, with an enlarged cut out portion A;

[0044] FIG. 2 is a side view of a prior art package, with an enlarged cut out portion B;

[0045] FIG. 3 is prior art compressing apparatus;

[0046] FIG. 4 is another prior art compressing apparatus;

[0047] FIG. 5 is a partial side perspective view of a package being formed in accordance with an embodiment of the invention;

[0048] FIG. 6 is a partial side perspective view of a package being formed in accordance with another embodiment of the invention;

[0049] FIG. 7 is a side schematic view of an apparatus in accordance with the invention in a winding position;

[0050] FIG. 8 is a side schematic view of an apparatus of FIG. 7 in a discharging position;

[0051] FIG. 9 is a top schematic view of an apparatus arrangement in accordance with an embodiment of the invention;

[0052] FIG. 10 is a top schematic view of another apparatus arrangement in accordance with the invention;

[0053] FIG. 11 is a top schematic view of an additional apparatus arrangement in accordance with the invention; and

[0054] FIG. 12 is a side view of a precompression apparatus in accordance with an aspect of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0055] The invention is described with reference to a package. It is to be understood that this description of a package is intended to cover various sizes of packages, ranging from large mill rolls to small rolls suitable for light industrial applications. It should also be understood that the material is described referring to a sheet or strip that is intended to include various configurations of materials generally formed in a mat, tape, web or elongate form. The strips can range from very narrow, for example several inches or about 10mm, to very wide, for example about ten feet or two meters.

[0056] For purposes of illustration, the particular type of material described herein is nonwoven materials, which can be similar to those described in the background section of this document. The nonwoven material referred to herein includes various materials formed of interconnected fibers that are not woven like a conventional textile. The materials tend to carry relatively large amounts of air between the interstices of the material fibers or elements. The nonwovens can include material that is fibrous, air laid, and/or compressible. The types of material include filtration media, cellulosic, polyester, polymeric, glass, spun bond, open cell foam, and composites that could include films. However, such description should not be deemed to limit the inventive concepts disclosed herein strictly to nonwoven materials. It is envisioned that the compression and packaging techniques could be used on various types of materials including films, foils, plastics, mechanical fastening tape, drawstrings, elastomerics, foams, and even textiles if desired.

[0057] A package 10 formed in accordance with this invention is shown in FIG. 1. The package 10 includes a core 12 with a strip of material 14 wound around the core 12 under compression, as will be discussed below. As seen by comparison to FIG. 2 in which a conventional package with no compression is formed, package 10 holds a significantly longer strip of material 14 than a conventional package 200. The strip 14 may be continuous, that is the strip 14 may be formed of a series of interconnected strips to form a continuous strip, which is more desirable in an end use manufacturing assembly so that frequent stopping for strip replenishment is not necessary. Various known ways of forming a continuous strip, including splicing, may be used.

[0058] The section A of FIG. 1 shows that the strip 14 is layered with uniform compression. The fibers 16 are more compactly arranged due to the removal of air from between the fibers 16. The compression is not so great, however, that the fibers 16 are broken or the properties of the strip 14 are changed. Various degrees of compression can be obtained depending on the particular material used. In this case, compression of about 6 to 1 is achieved. It will be appreciated that this offers significant savings in terms of storage and transportation and manufacturing efficiency due to a reduction in change over and down time.

[0059] It has been discovered by this inventor that nonwoven materials may be compressed using a uniform pressure that consistently surrounds the material 14 as it is being wound on the core 12 to a certain degree without experiencing deleterious effects on the properties of the nonwoven material. By gently removing the air from between the fibers 16 and applying a uniform pressure around the core 12, the material 14 reduces thickness

without breaking the fibers 16. This a much more complex process than merely baling a strip of material by simply rolling the material within an enclosure to wrap subsequent layers around inner layers. This is also a significant change from pressure point compression, as illustrated in FIGs. 3 and 4, that applies a small area of high pressure that broke fibers and compromised the quality of the material.

[0060] As will be appreciated from this disclosure, the tension in the wound strip is reduced to a minimum value that is necessary to just carry the material 14 to the compression area between the package 10 and the guide roll, described below. As the winding progresses, it is desirable that the material 14 remains at a constant tension and compression throughout the length of the material 14 within the package 10.

[0061] Upon use, the material 14 from packages 10 formed in accordance with this invention exhibit no harmful effects from the compression. Further, when opened, the packages 10 gently expand or rebound without exhibiting a popping or springing effect that is difficult to manage in a manufacturing environment. This is a result of compressing the material 14 without tensioning the strips so the potential energy in the strips 14 causes the fibers 16 to expand with respect to each other allowing air into the interstices, and not rebound from tension in the strips 14.

[0062] The basic concept of winding the material 14 while compressing is shown in FIGs. 5 and 6. The embodiment seen in FIG. 5 uses a belt 18 that extends substantially the entire length of the core 12. The strip of material 14 is fed between a pair of rolls 20 and 22 onto the core 12. The belt 18 is driven and wraps the strip of material 14 around the core 12 by friction. It should be understood that the strip of material can be any width, and although shown as a thin strip it could extend the length of the core.

[0063] Preferably, the belt 18 is formed as an endless sheet of material that has a high tensile strength. An example of a suitable material is a woven urethane bottom that functions as the drive surface and a urethane top surface that is "sticky" or has a high coefficient of friction that contacts the strip of material. A preferred material for belt 18 is impervious PVC. It is also possible to use a belt that is formed as a screen, is semi-permeable or is perforated to allow visual inspection of the package 10 during formation. Of course, any other suitable material may be used for the belt 18. It is also contemplated that the belt 18 can be formed as plural belts, each forming a segment of a belt system that forms a full circle around the core 12.

[0064] FIG. 6 shows an alternate belt arrangement in which a narrow belt 24 that is approximately the width of the strip 14 is used. In this case, the belt 24 still fully surrounds the strip 14 as it is fed between rolls 26 and 28 to be wound on the core 12.

[0065] It will be appreciated that in this arrangement, it is possible to accurately control both the tension in the belt 18, 24 and the pressure between the package 10 and the rolls 20 and 22, 26 and 28 where the compression occurs. By this, all of the required compression in the material 14 from its normal or at rest thickness down to the desired compressed thickness occurs in the area between the package 10 and the rolls 20 and 22, 26 and 28 between which the material 14 passes. At this point the air is expelled from the interstices of the material 14 allowing it to compress to the desired thickness. The belt 18, 24 exerts a continuous force against the package 10 throughout rotation of the package 10 from the point at which the material 14 is applied through 360° of rotation until the next layer is applied over the underlying layer.

[0066] FIGs. 7 and 8 show a winding apparatus 40 in accordance with one embodiment of the invention. The winding apparatus 40 includes a frame 42 supported on a surface and a core support 44 that supports the core 12 of the package 10. The core support 44 can take various forms including an elongated spindle or a pair of axles, for example. The core support 44 is carried on a discharge rail 45. The frame 42 supports a belt support system, in this case rolls, that support and drive the belt 18. A belt tensioning device 46 is also provided.

[0067] The belt 18 support system is formed by a series of rolls, which could also be pulleys, including rolls 48 and 50 at the base of the frame 42, rolls 52 and 54 at the top of the frame 42, feeder rolls 56, 58, 60, and 62 and tensioning roll 64. Rolls 56 and 58 are carried on a pivoting upper arm 66, and rolls 60 and 62 are carried on a pivoting lower arm 68 connected at pivot joint 70. Arms 66 and 68 are controlled by pistons 72 and 74 that are mounted to a support rail 78. One or more of the rolls are driven so as to turn the endless belt 18 around the path of rolls. In this case, for example, roll 50 is driven. However, another roll in the assembly could function as the driving roll.

[0068] Belt tensioning device 46 also consists of a series of rolls, or pulleys, mounted on a driven rod 80. Rod 80 can be any driven device, but in this case is a pneumatic piston with a pulley 82 on one end. Rolls 84, 86, and 88 are mounted on the frame 42 and form a path for a tensioning strap 90. The strap 90 extends from tensioning roll 64 around rolls 88,

86, and 84 to pulley 82 and is then mounted to roll 52 or any other fixed point on the frame 42. The tensioning device 46 may be manually controlled or may be connected to a controller C that is programmed to control driven device 80 to tension and release the belt 18, as discussed below.

[0069] Preferably, the core 12 is supported so that it can move naturally in response to the increasing diameter of the package 10. However, if desired, the controller C can control the position of the core 12 to affect the tension in the belt 18 and, thus, the pressure on the package 10. The controller C detects the core 12 speed and then determines the belt 18 tension. The position of the core 12 can be then moved to counterbalance the tension in the belt 18. This control is especially useful if the material 14 is buckling between the rolls 58 and 60. The core 12 position can also be controlled to assist in removal of the package 10, as discussed below.

[0070] An anti-static device can be provided on the winding apparatus 40 to dissipate static charges generated during winding by the belt 18. FIG. 7 shows a metal screen 92, preferably covered by a shield such as Plexiglas, disposed on one side of the apparatus 40 that dissipates static charge from the belt 18 by gathering charge as the belt 18 passes by the screen 92. Of course, any anti-static arrangement can be employed with the a similar effect.

[0071] If desired, an edge guide 94 can also be provided to monitor the position of the edge of the belt 18 and control wandering. As the belt 18 rotates at high speeds, it can have a tendency to wander to one side or the other. Such wandering adversely affects the tension in the belt 18 and compromises the uniform pressure and growth of the package 10. An example of a suitable edge guide is an optical position detector. A commercially available system suitable for use with the apparatus 40 is an Fife edge guide system, which is a commercially available dynamic guide that repositions the center line of the belt 18 by twisting the belt 18 by adjusting the position of one or more of the rolls.

[0072] In operation, the belt 18 extends around rolls 48, 64, 50, 52, 54, 56, and 58 and then around core 12 of package 10 and out to rolls 60, 62, and back to roll 48 in an endless loop. As roll 50 is driven, the belt 18 receives an end of the strip 14 between rolls 58 and 60 and catches the strip 14 between the belt 18 and the core 12. As the belt 18 is driven around the apparatus, the strip 14 is wound around the core 12. As the package 10 diameter increases, the belt 18 expands around the material 14 to exert an even compressive force on the package 10. The expansion is accommodated by the belt tensioning device 46.

[0073] The belt tensioning device 46 operates as follows. The tension in the belt 18 is varied based on the position of roll 64. Roll 64 rides on support rail 78. The position of roll 64 is determined by the tensioning strap 90, which travels from roll 64 around rolls 88, 86, and 84 to pulley 82. Pulley 82 is moved by driven rod 80. FIG. 7 shows the fully retracted position of rod 80 in which the roll 64 is at its lowermost position and the package 10 is fully formed. To shorten the belt 18 around the package, the roll 64 is pulled upward on rail 78 by extending rod 80 and lowering pulley 82.

[0074] Ideally, the length of the strip 14 is not changed after it is applied to the package 10 by allowing the diameter to expand, thus potentially damaging the material by inducing tension in the material of the strip 14. Thus, the tension in the belt 18 is maintained to match the expansion forces generated at all points throughout the package 10. It is apparent that the tension in the belt 18 will increase as the diameter of the package 10 increases. So, the tension in the belt 18 will, in theory, increase in direct proportion to the diameter to maintain a constant pressure on the surface of the package 10. However, in reality, the pressure must vary to accommodate the changing expansion forces generated by the package 10, especially as the expansion forces change based on the amount of material 14 supported on the core 12 and the inherent spring force generated by the material 14.

[0075] The tension in the belt 18 must be properly controlled in view of these factors to resist the tendency of the strips 14 to increase or decrease in length as the diameter of the package 10 at that particular layer tends to increase or decrease due to subtle differences in expansion or collapse of the package. If the belt 18 is improperly tensioned, the package 10 will tend to expand or collapse thus causing the strips 14 to increase or decrease in length, which could damage the material, especially since there is high friction between the layers of a nonwoven that entrap air and resist slipping.

[0076] It is also desirable to maintain a constant strip 14 thickness while building the package 10. The layers of strips 14 will tend to expand or contract to maintain a constant thickness between the layers as the forces will be distributed between the layers thus averaging out the compressive forces and the actual amount of compression.

[0077] To release the package 10, roll 64 is pulled by tensioning strap 90 to its uppermost position, as seen in FIG. 8. This shortens the belt 18 to its minimum extent and pushes arms 66 and 68 to pivot about joint 70, thereby compressing pistons 72 and 74. Package 10 is then permitted to travel outward on discharge rail 45 for removal from the

apparatus. When the belt 18 is slackened, the pistons 72 and 74 urge the arms 66 and 68 into the closed position.

[0078] It is preferred that the rolls 58 and 60 be disposed close together to avoid the material 14 from bulging outward between rolls 58 and 60. However, depending on the degree of desired compression, it is not necessary that rolls 58 and 60 be disposed close together. The degree of compression is determined by using parameters of the material 14 being wound. Based on prior testing of the material to determine the point at which the fibers 16 break down or other characteristics of the material change, the belt 18 is tensioned to impart the maximum pressure the package 10 can withstand without damaging the material 14, particularly the fibers 16. By this, the most efficient size package 10 can be produced. As consistent pressure is applied by the belt 18, compression is substantially uniform throughout each layer of material 14.

[0079] It should be understood that various modifications can be made to this apparatus, including using a narrow belt 24 and using a different tensioning device, if desired. It is possible to feed the material at any position also. Although FIG. 7 shows material being fed from the side, it is also possible to feed the material from below or above.

[0080] The material supply used to supply the strip 14 to the apparatus 40 can vary. FIGS. 9-11 show three possible arrangements. It is also possible to supply material directly from the point of manufacture, in other words to use the apparatus 40 to initially package the material on a master roll.

[0081] Referring to FIG. 9, the material supply includes a wound sheet of material 100 supported on a supply support 102. The supply support 102 includes a supply driver 104 that drives the material supply 100 and controls the tension of the strip 14. It is preferred to supply the strip 14 with minimal tension, ideally no significant tension. The ideal tension will supply the material 14 without creating slack or becoming taut. For example, a preferred negligible tension would be one ounce per inch. Any type of supply support 102 can be provided as long as a stable support is present. The supply driver 104 can also take any form, such as a driven roll. It is not necessary to provide a supply driver 104, but its presence assists in smoothly supplying the material 14 with negligible tension.

[0082] The material supply may also include a separator 106, which may be any device that divides the sheet of material 100 into strips. One such device is a slitter. Alternatively, as seen in FIG. 11, the material supply 100 may already be separated into strips.

[0083] FIG. 9 shows an arrangement in which each strip 14 is fed to an individual winding apparatus 40. By this, a plurality of packages 10 can be made simultaneously. FIG. 10 shows an arrangement in which each strip 14 is fed to a single core 12. By this, a plurality of rolls 10 can be formed as a single package 110. In this case, a single belt 18 or multiple belts can be used.

[0084] FIG. 11 shows an arrangement in which a single strip 14 is fed for traverse winding across the length of a single core 12 to form a roll or spool 120. To accomplish traverse winding, one of the supply 100 or the core 12 is moved so that the strip 14 is wound across substantially the entire length of the core 12. This enables a large amount of material to be carried on a single core. FIG. 11 shows the core of package 120 moving, however, it is also possible to move the supply 100 or to have a traverse feeder that moves the strip 14. Such traverse winding is also possible with the arrangements in FIGs. 9 and 10. In addition to traverse winding, it is possible to use step winding in which individual spiral wound rolls are wound on a core interconnected with strips. The winding in this case is accomplished in a stepped fashion so that the rolls are wound in sequence across the core, building each stack gradually. This technique is described in U.S. Patent Re. 32,608, which is incorporated herein by reference.

[0085] While in the embodiment described above, the material 14 is not precompressed, it may be desirable in certain situations to precompress the strip 14. In that case, the precompression would be effected with a gentle or gradual compression so as not to damage the material, as occurred in the prior art. For example, it is possible to employ a series of nips progressively spaced closer and closer together to achieve a gentle precompression prior to feeding the material to the belt compressing device. It is also possible to compress the material with a belt carried on a drum.

[0086] A preferred way of precompression, if desired, is by vacuum, which also acts as a feeding control mechanism both holding the material in place and subjecting a compressive force that draws the air out of the material before it enters the apparatus 40. FIG. 12 shows a vacuum precompression system 130 including a frame 132 that supports a carriage 134 on a rail 136 and a driving mechanism 138, in this case a driven threaded rod. The carriage 134 slides transversely with respect to the frame 132 and the winding apparatus 40 to feed the strip 14 either traversely to form a spiral wound package or in a stepped fashion to form plural pancake stacks. The carriage 134 supports a driven belt 140 that extends between a plurality of rolls 142, at least one of which is preferably driven to provide

an even supply speed to the material and avoid tensioning or bunching the material as it is being fed to the winding apparatus 40. A vacuum drum 144 connected to a vacuum source V is mounted adjacent the driven belt 140. The strip of material 14 is fed between the belt 140 and the vacuum drum 144 thereby drawing air from the material to cause compression. This precompression assists in achieving a highly compressed package 10 but is not necessary to form a package 10 in accordance with this invention.

[0087] If desired, the same apparatus described above can be used to unwind the package 10 at an end use station so that the package 10 can be accurately driven by a belt based on the measured tension at the pay-off or measured required line speed. The package 10 can be braked and driven at exactly the required speed without tensioning the strip 14 so that the strip 14 can be paid off at a very low or minimum tension. By this, expansion of the package 10 can be controlled precisely in a symmetrical manner to the winding action to prevent uncontrolled expansion of the layers creating localized stretching and potential damage of the material 14. It should be noted, however, that packages 10 wound by this method without tension induced in the strips 14 naturally hold their shape and are formed as stable structures due to the coefficient of friction between the layers. The packages 10 in accordance with this invention do not necessarily require exterior wrapping as they resist uncontrolled expansion and do not exhibit a springing or popping effect when unbound.

[0088] The types of packages that can be made using this method and/or this apparatus include rolls carrying extremely long lengths of material. For example, the strip of material 14 may range from 5,000 feet to 100,000 feet or more. The package 10 may be a small roll of several feet diameter or a large roll, 3 feet wide with a diameter of 4 feet, for example. The material can have any thickness. The method is particularly suited for strips having a thicknesses of about 5mm, 3mm, or 1mm, for example. The width of the strip may also vary and can range from the length of the core to thin strips of 25cm or 10cm. The material may also have various weights. For example, the weight may range from 20 grams per square meter (gsm) to 500 gsm or 40 to 50 gsm. The method is particularly suited for high speed operation, as in an industrial setting. For example, the material may be wound at speeds up to 500 meters per minute. These values are not intended to be limiting, but to merely provide examples of suitable material for this invention.

[0089] Various modifications and changes may be made within the scope of the invention. As noted above, the method and apparatus are suitable for a wide variety of materials, especially compressible materials. The method may be used to make single or

multiple packages that are packaged singly or together. The apparatus may be adapted to accommodate different compression requirements and may vary based on different type of supply arrangements. It may be used at the initial phase of forming the material and creating a master roll and/or may be used in downstream operations including separating smaller widths of material from the master roll or even by an end use manufacturer that handles only small rolls of material.